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Contents

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Original Article

Accessibility of Shopping Malls for Mobility-Impaired People in Jeddah 2018

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Abstract:

BACKGROUND: Improving the accessibility for individuals with mobility impairments is a key aspect of occupational therapy in enhancing their quality of life. Shopping malls are an essential part of entertainment venues that must be accessible for a variety of individuals in the community. **OBJECTIVE**: The objective of this study was to evaluate the accessibility of shopping malls in Jeddah, Saudi Arabia, with the aim of identifying potential improvements to enhance the quality of life for individuals with physical disabilities. **MATERIALS and METHODS:** A total of twenty-four shopping malls as listed in Jeddah Municipality were included in this study. Senior occupational therapy students assessed accessibility of parking, routes, entrances, elevators, ramps, and restrooms for included facilities using the Americans with Disabilities Act Checklist for Readily Achievable Barrier Removal. **RESULTS:** The findings indicated that 75% of shopping malls in Jeddah were compliant with accessibility standards. The highest score, 90%, was achieved by two malls out of a total of twenty-four, while the lowest score recorded was 55%. Seventy-nine percent of the route pathways complied with the guidelines, while 71% of the entrances met the accessibility standards. Ramps demonstrated 63% compliance, while elevators showed 38%, corresponding to 33% compliance for parking facilities. Restrooms had the lowest compliance, with a score of 14%. **CONCLUSION:** Shopping malls in Jeddah need enforcement policies to improve accessibility and quality of life for individuals with impaired mobility.

Keywords: Accessibility, Physical Disability, Impairment, Shopping Malls, Mobility

Introduction

The number of people living with a disability is significantly high. A recent update from the World Health Organization (WHO) indicates that individuals with disabilities represent approximately 25% of the global population. [1]. The General Authority for Statistics of Saudi Arabia (GAStat) recognizes individuals with disabilities as a significant portion of the population, comprising 7.1% of the total Saudi population [2]. In Saudi Arabia (SA), mobility and physical impairments are the most common types of disabilities, accounting for 29.13% of the population with disabilities [2,3]. These numbers highlight the importance of investigating the level of accessibility in certain public places [3]. The Unified National Platform of SA outlines the rights of individuals with disabilities, with a commitment to ensuring a decent and dignified life for all citizens and residents [3]. This includes improving service delivery in key areas such as protection from harm, social care,

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rehabilitation centers, healthcare, and equal access to education. Additionally, it emphasizes initiatives for employment, mobility and transportation, accessible facilities and parking, sign language support, housing, and mobile services dedicated to individuals with disabilities [4]. Disability law and regulations in SA helps persons with disabilities to achieve independence and participate actively in society by giving them access to a barrier-free environment [5]. However, in practice, accessibility of public places for persons using wheelchairs in SA is extremely poor or absent due to architectural barriers in the built environment [5]. There is an acute restriction of accessibility in SA to public roads and buildings to individuals using wheelchairs [5].

To enhance public spaces in Saudi Arabia for individuals with disabilities, occupational therapists must assess the current level of accessibility. Occupational therapy is in a unique profession in contributing to the development and fulfilment of participation for persons with and without disabilities [6]. Occupational therapy has a key role in supporting community mobility, particularly for individuals with impairment and activity limitations [7]. Occupational therapy practitioners focus on helping individuals with mobility impairments gain independence in various settings [8]. Accessibility is the quality of access as well as the ability to use and benefit from the services within the environment [9]. The primary requirement for mobility is physical accessibility, supported by effective legislation, to ensure a safe pathway to social inclusion [9].

Rehabilitation and occupational therapy services aim to address patients' needs and promote independence in all aspects of daily life. This includes encouraging patients' reintegration into the community by facilitating social and functional interactions with others and their surrounding environment [10]. Several studies have been conducted in various regions of Saudi Arabia regarding accessibility for individuals with physical disabilities, with the majority focusing on the accessibility of mosques [11, 12, 13]. Mosque is a place where Muslims can come together for prayer, as praying together holds significant importance in Islam [14]. In Riyadh, the capital city of Saudi Arabia, mosques were found to be inaccessible for wheelchair users. Similarly, compliance scores for mosques in Jeddah were also found to be low [12]. Mosques in the Al Ahsa region were also found to be inaccessible for wheelchair users, hindering individuals with physical disabilities from participating in religious activities at mosques [13]. The current situation forces prayer with physical disability in isolation in their houses, preventing them from participating in an important part of their faith [11, 12, 13]. On the other hand, a study conducted at King Abdulaziz Medical City in Riyadh found that more than two-third of people with disabilities are willing to visit KAMC due to the high accessibility [15].

Accessibility is a fundamental prerequisite for individuals with disabilities to fully enjoy their human rights, live independently, and participate equally in the community [16]. Occupational therapy is a professional practice that is both philosophically and epistemologically grounded in the multidimensional nature of individuals in action within a given context [17]. As such, assessing accessibility becomes a key area of intervention for occupational therapists [17]. Practitioners of occupational therapy have a crucial role in facilitating the integration of individuals into the environments with using social participation-based interventions to focus on enabling people to explore and expand on social support in their society [18]. Therefore, the purpose of this study was to investigate the level of accessibility in shopping malls that are considered as one of the major entertaining facilities in Jeddah city.

Materials and Methods

Study Design

This study employed a descriptive design [19], which was deemed appropriate for observing and documenting information, as well as gathering preliminary data to support future research [19]. The study was approved by the King Abdullah International Medical Research Center (RYD-18-417780-172379).

Sittings

A total of twenty-four shopping malls as listed in Jeddah Municipality were included in this study. The administrative malls that agreed to participate provided informed consent before the environmental assessment was conducted, ensuring that the anonymity of the malls was maintained throughout the process. The inclusion criteria for the study were malls located within the Jeddah region and officially listed in the Municipality.

Procedure

This study was conducted over a three-week period at malls in the Jeddah region, with one to two malls assessed each day. A team of senior students from the occupational therapy program carried out the assessments. The malls were selected based on their location, and the team evaluated them accordingly.

Instrument measure

The ADA Checklist for Readily Achievable Barrier Removal for Existing Facilities is based on four priority areas: (1) Accessible Approach and Entrance, (2) Access to Goods and Services, (3) Usability of Restrooms, and (4) Additional Access [20]. The criteria for the ADA assessment are typically answered with a "yes" or "no" response [20]. The investigators used this checklist to evaluate the accessibility of parking, routes, entrances, elevators, ramps, and restrooms in existing facilities through direct observation and measurement.

Data analysis

Descriptive statistics and frequency analysis were conducted to outline the general characteristics of the study findings. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) V26 2019 program, with simple descriptive statistics summarized as frequency and percentage [21]. The frequency and percentage values reflect the compliance of buildings with the items listed in the ADA checklist's accessibility areas. Each priority area in the checklist is further divided into subsections, with percentages used to present the findings for each specific area.

Results

A total of twenty-four out of twenty-five shopping malls met the inclusion criteria for the study, with one mall listed in the Jeddah Municipality still under construction. None of the malls included in Jeddah were fully compliant with all the items on the ADA checklist.

Two shopping malls achieved the highest overall compliance score of 90.1%, while the mall with the lowest compliance score received 50.5%. The compliance scores of all malls were categorized into ranges. The results were rounded to the nearest whole number, as shown in (Figure 1).

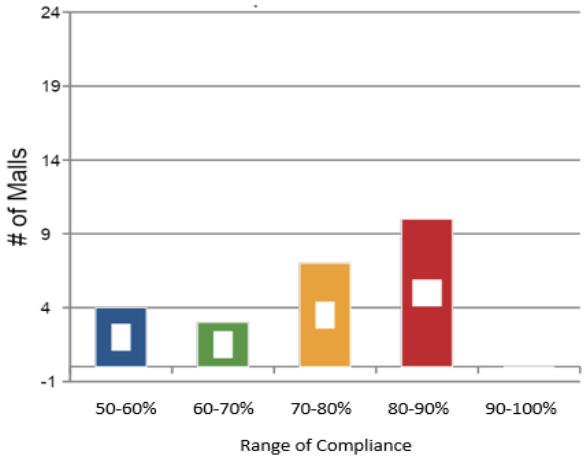
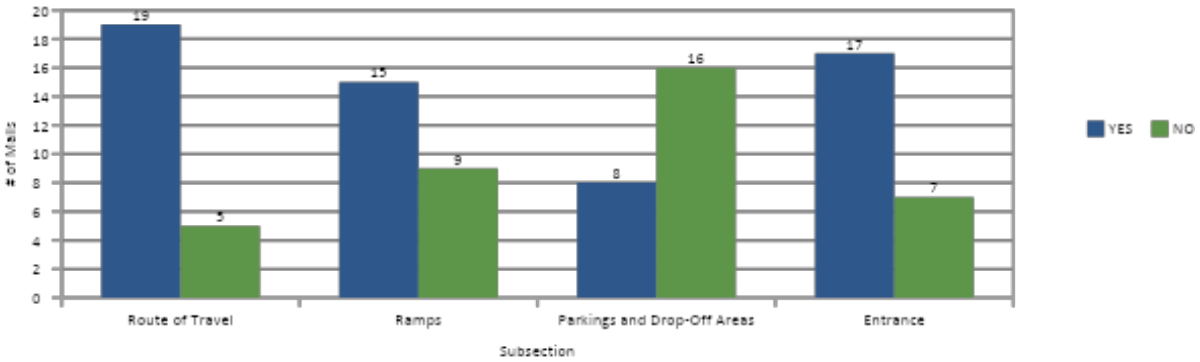


FIGURE 1: THE COMPLIANCE SCORES OF ALL MALLS CATEGORIZED IN RANGES WITH APPROXIMATION

The findings were described according to the checklist subsections within each of the four priorities. The first priority, Accessible Approach/Entrance, consists of four subsections: (1) Route of Travel, (2) Ramps, (3) Parking and Drop-Off Areas, and (4) Entrance (19). Most malls in Jeddah exhibited higher standards for routes, ramps, and entrances compared to parking and drop-off areas, as shown in (Figure 2).

Access to Goods and Services consists of twelve subsections: (1) Horizontal Circulation, (2) Doors, (3) Rooms and Spaces, (4) Emergency Egress, (5) Signage for Goods and Services, (6) Directional and Informational Signage, (7) Controls, (8) Seats, Tables, and Counters, (9) Vertical Circulation, (10) Stairs, (11) Elevators, and (12) Lifts. (11)

FIGURE 2: THE RESULTS OF THE FOUR SUBSECTIONS: (1) ROUTE OF TRAVEL (2) RAMPS (3) PARKING AND DROP-OFF AREAS, AND (4) ENTRANCE



More than half of the malls included in this study exhibited positive compliance with building standards in the first seven subsections of Access to Goods and Services (Figure 3). However, specific questions, such as those pertaining to Braille language, impacted the study's findings in the categories of Signage for Goods and Services, Controls, and Elevators, despite their limited relevance to individuals with mobility impairments (Figure 4). After excluding questions unrelated to individuals with physical impairments, calculations were performed on the revised list of relevant items (Figure 5).

The compliance of malls was higher in the final two subsections: (1) Directional and Informational Signage, and (2) Seats, Tables, and Counters (Figure 6).

The usability of restrooms, including categories such as Getting to the Restrooms, Doorways and Passages, Stalls, and Lavatories, showed low compliance in all four areas across the included malls. No malls were compliant in the Stalls subsection, as shown in Figure 7.

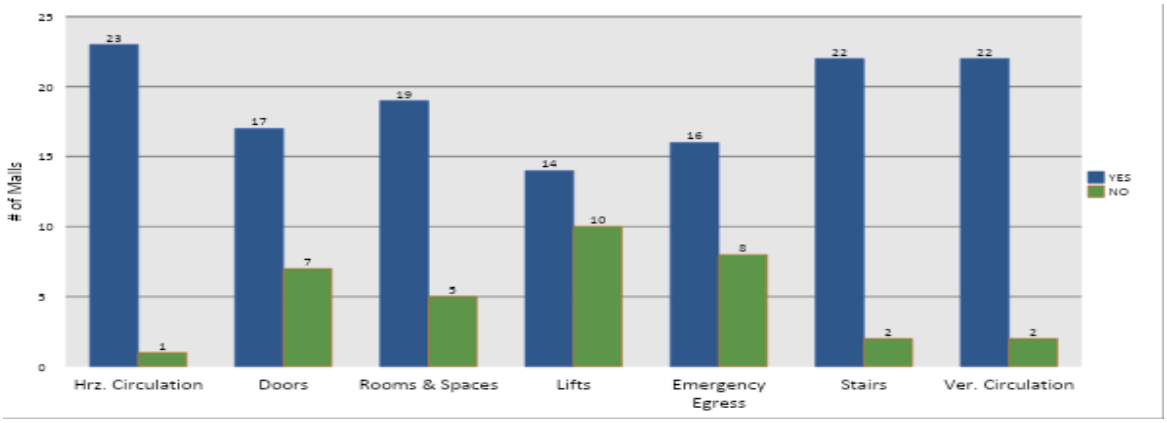


FIGURE 3: THE RESULTS OF ACCESSING TO GOODS AND SERVICES

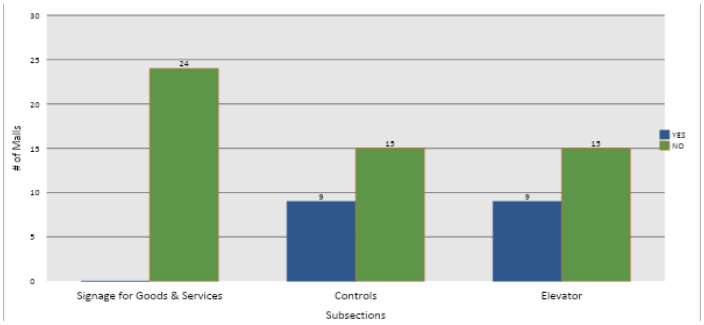


FIGURE 4: CATEGORIES WERE NOT FULLY RELATED TO POPULATIONS WITH MOBILITY IMPAIRED

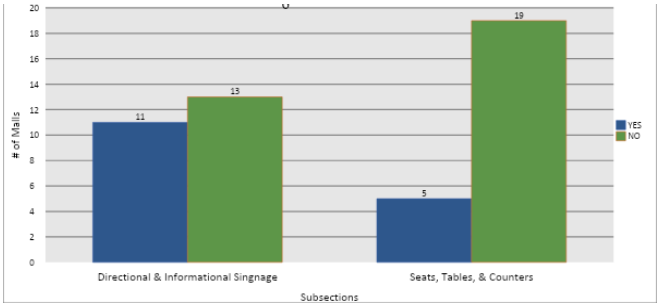


FIGURE 6: THE FINDINGS OF THE LAST TWO SUBSECTIONS

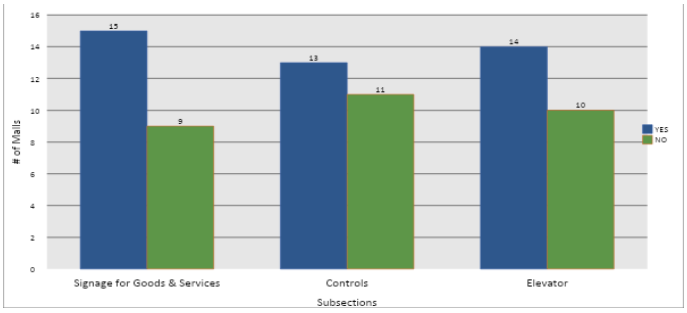


FIGURE 5: THE RESULTS AFTER EXCLUDING UNRELATED QUESTIONS TO PERSONS WITH PHYSICAL DISABILITY

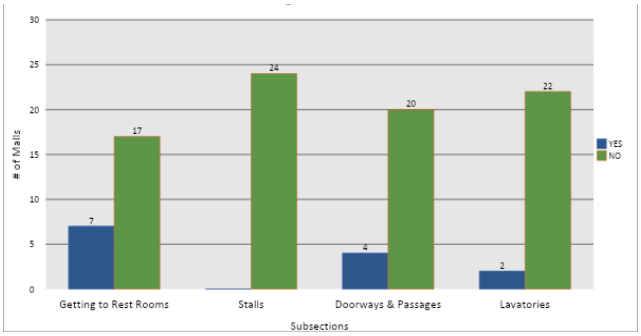


FIGURE 7: THE RESULTS OF USABILITY OF REST ROOMS INCLUDES GETTING TO THE REST ROOMS, DOORWAYS AND PASSAGES, STALLS, AND LAVATORIES

The final priority, Additional Access, includes categories such as Drinking Fountains and Telephones. This priority is relevant to institutions that provide these facilities; however, it was not applicable to any of the malls in this study. As a result, this priority was not included in the total score calculation, as shown in Figure 8.

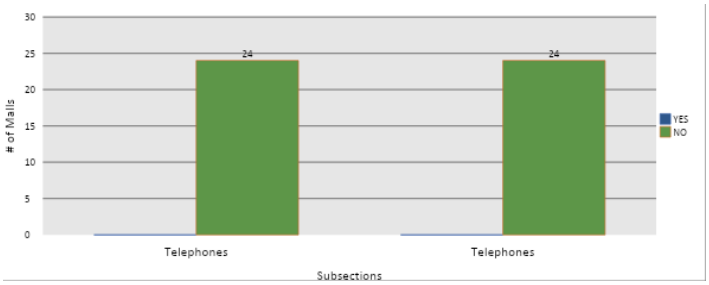


FIGURE 8: ADDITIONAL ACCESS CATEGORY'S RESULTS

Discussion

This study aimed to assess the accessibility of shopping malls in Jeddah, as these malls are key recreational facilities in the city, and everyone has the right to access them. The results indicated that shopping malls in Jeddah are not fully accessible for individuals with mobility impairments and need to comply with ADA standards to ensure equitable access.

The results of the current study indicated that none of the malls achieved 100% compliance with ADA requirements. The two malls with the highest compliance scored 90%, while the lowest score was 50%. The highest compliance percentage was observed in mall routes, with 79% compliance. Ramps showed 63% compliance, with the majority failing to meet international standards, particularly in terms of width. Parking facilities had the lowest level of accessibility, with only 33% compliance. Some of the assigned malls did not implement measures to ensure that parking spaces were reserved for individuals with disabilities, while others did not provide designated parking for this population. The entrances and travel routes in the included Jeddah malls showed 71% accessibility.

Our results also indicated that the elevator section scored 38% compliance. The elevator control buttons were not positioned at an accessible height for individuals with mobility impairments, nor was the emergency button reachable. Restrooms were found to be significantly inaccessible in all the malls assessed, with only a 14% compliance level. Most malls that provided restrooms for individuals with physical disabilities had issues such as inappropriate toilet heights or the absence of grab bars, which could compromise safety. Most of the restroom lavatories did not have suitable knee clearance for people using wheelchairs to access and using. There were no signs indicating alternative directions to accessible restrooms at the malls with inaccessible restroom facilities.

The results also indicated that the additional access features, such as telephones and drinking fountains, were excluded from the data analysis, as they were not provided in Jeddah malls. The absence of these features did not impact the level of accessibility for the targeted population, as neither individuals with disabilities nor the general public had access to these services. Overall, the compliance rate was 75%, which included routes, entrances, ramps, parking, elevators, and restrooms.

The current study is one of the first to focus on the accessibility for individuals with mobility impairments in SA. It aligns with the objectives of the 2030 Vision, which emphasizes equality and aims to improve all aspects of life [22]. The sample size is highly representative, covering 96% of the population across all geographical regions. However, the ADA checklist used does not include a standard reference guide for determining the minimum accessibility requirements for shopping malls catering to individuals with mobility impairments.

Future research should focus on investigating the accessibility of public buildings such as government offices, banks, and gyms. Key areas for modification include hospitals, schools, daycare centers, and mosques. Given that individuals with physical disabilities are often reliant on accessing public buildings, it is crucial to address these spaces. Additionally, conducting similar research in other cities across SA is recommended to gain a comprehensive understanding of accessibility challenges nationwide.

Conclusion

The current study presents discouraging results, highlighting the need for stronger enforcement of policies to improve the accessibility of shopping malls in Jeddah. These findings are significant in the current context and may contribute to enhancing accessibility in the construction of future buildings while increasing awareness among the relevant authorities. Additionally, further research should be conducted on other public facilities to ensure that buildings are made accessible to individuals with mobility impairments.

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Ethical approval statement

The study was approved by the King Abdullah International Medical Research Center (RYD-18-417780-172379).

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This study was conducted without external financial support.

Conflicts of interest

The authors report no conflicts of interest in this work.

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إمكانية الوصول إلى مراكز التسوق للأشخاص ذوي الإعاقة الجسدية في مدينة جدة 2018

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المستخلص:
الخلفية: إن إتاحة الوصول للأشخاص ذوي الإعاقة الحركية يعد أحد أدوار العلاج الوظيفي في تحسين نوعية الحياة. وتعتبر مراكز التسوق جزءًا أساسيًا من أماكن الترفيه التي يجب أن تكون متاحة لمجموعة متنوعة من الأفراد في المجتمع. **الهدف:** هدفت هذه الدراسة إلى معرفة مستوى إمكانية الوصول إلى مراكز التسوق في مدينة جدة بالمملكة العربية السعودية، بهدف تحسين جودة الحياة للأشخاص ذوي الإعاقات الجسدية. **المواد والطرق:** تم تضمين إجمالي أربعة وعشرين مركزًا تجاريًا مدرجًا في بلدية جدة في هذه الدراسة. قام طلاب العلاج الوظيفي في السنة الرابعة بتقييم إمكانية الوصول إلى مواقف السيارات والطرق والمداخل والمصاعد والممرات والمراحيض للمرافق المشمولة لمراكز التسوق باستخدام مقياس قائمة التقييم الأمريكية المخصصة لإزالة العوائق البيئية لذوي الإعاقة. تم استخدام برنامج الحزمة الإحصائية للعلوم لتحليل البيانات ووصف الإحصائيات والنسب المئوية. **النتائج:** أظهرت النتائج أن 75% من مراكز التسوق في جدة كانت متوافقة مع المعايير. أعلى نسبة مئوية من التوافق هي 90% من بين أربعة وعشرين مركزاً تجارياً، بينما كانت أقل درجة 55%. مسارات الطرق متوافقة مع المقياس بنسبة تسعة وسبعون في المئة 79%، وكانت المداخل ملائمة بنسبة 71%. بالنسبة إلى المنحدرات المخصصة لكراسي ذوي الإعاقة الجسدية فقد كانت متماثلة بنسبة 63%، في حين أظهرت المصاعد توافقاً بنسبة 38%. مواقف السيارات كانت متوافقة بنسبة 33% بينما حصلت دورات المياه على الحد الأدنى من التناسب بنسبة 14%. **الخلاصة:** تحتاج مراكز التسوق في جدة إلى تدخل من الجهات المسؤولة لتحسين إمكانية الوصول وجودة الحياة للأشخاص ذوي الإعاقة الجسدية .

الكلمات الدالة: إمكانية الوصول، مراكز التسوق، التنقل، الإعاقة الجسدية، الإعاقة.

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Original Article

Balance deficit among diabetic polyneuropathy Saudi patients

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Abstract:

BACKGROUND: Currently, the risk of fall is high among diabetic patients in Saudi Arabia. Nowadays, the interest is direct towards prevention of fall through the prospective research studies trying to reduce the fall risk. **OBJECTIVE**: The present study was intended to detect the fall incidence among diabetic Saudi patients with polyneuropathy. **MATERIALS and METHODS:** A total of 200 Saudi patients with type 2 diabetes mellitus, aged between 40 and 55 years, were enrolled in the study and divided into two distinct groups. One group consisted of individuals diagnosed with diabetes, while the other group included those with established peripheral neuropathy, referred to as the Diabetic Peripheral Neuropathy (DPN) group. The diagnosis of diabetes was made in accordance with clinical guidelines. To assess balance performance, participants underwent three established evaluation tests: the Functional Reach Test (FRT), the Timed Up and Go Test (TUG), and the Berg Balance Scale (BBS). **RESULTS:** There were significant differences between groups have been detected for BBS and FRT which was significantly lower for diabetic patients with peripheral neuropathy compared with diabetic patients. While significant higher values for diabetic patients with peripheral neuropathy were also detected for TUG compared with diabetic patients. **CONCLUSION:** Diabetic patients with peripheral neuropathy had more balance deficit than diabetic patients without peripheral neuropathy.

Keywords: Balance, Type 2 Diabetes Mellitus, Diabetic Peripheral Neuropathy

Introduction

Globally, it is estimated that the number of individuals with diabetes will exceed 350 million by 2030, largely driven by the global increase in obesity, which has contributed to a growing prevalence of type 2 diabetes mellitus (T2DM) [1]. Furthermore, diabetes is responsible for approximately 5.2% of all deaths worldwide [2]. Without concerted efforts to address the pathogenesis and treatment of this syndrome, the harmful macrovascular and microvascular outcomes of T2DM will remain a major burden for decades to come [3].

Polyneuropathy is one of the most prevalent serious consequences of diabetes that may cause many health-related complications amputations among diabetics [4]. The most frequent signs of poor polyneuropathy are abnormal sensations such as pain, loss of sensation, numbness, balance, sensation of instability and increase the risk of fall that is

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may be induced by gait deviations as decrease cadence and step length [5,6]. In addition, decreases in movement perception of the hip and ankle joints can induce static and dynamic balance instabilities and thus increase the risk of falling [7-9].

Peripheral sensations are found to be abnormal associated with muscle weakness among the diabetic patients who suffer from polyneuropathy which are the main cause of instability and fall among these patients [10,11]. There is a limited amount of research that compares balance performance between individuals with diabetes who have polyneuropathy and those who do not [12, 13]. Therefore, this research will report and keep records of accidents and incidents of fall that occur among diabetic Saudi patients with polyneuropathy.

Materials and Methods

Subjects

Two hundred patients with T2DM were randomly participated in this study, their age ranged from 40-55 years. The diabetic patients were included in two equal groups: The first group included type 2 diabetic patients with peripheral neuropathy, while the second group was type 2 diabetic patients without peripheral neuropathy. Diabetic Neuropathy Examination (DNE) was used to discriminate between patients with and without DPN [14-16]. The baseline and clinical criteria of all participants are presented in Table 1. All participants were out-patients of the Internal Medicine Department, King Abdalaziz University Hospital. This study had Faculty of Medical Rehabilitation Sciences Research Ethics Committee approval, and a written consent was signed by all participants.

Exclusion criteria included history of foot ulcers, internal otitis (labyrinthitis) or any other vestibular dysfunction, dizziness, vision impairment, musculoskeletal, neurological, or rheumatic disorders out of diabetes etiology, history alcohol intake, peripheral vascular disease, use of walking aids, nondiabetic neuropathy, cardiovascular disease, renal and hepatic dysfunction.

Methods

1. Evaluated parameters

A. Berg Balance Scale: Berg Balance Scale (BBS) is an assessment tool for both dynamic and static balance performance. The BBS required no specific training and little equipment as stopwatch, chair, step, ruler and space. Finally, health care personnel were only permitted to conduct the BBS in order to had the knowledge about how to mobilize patients safely [17- 19].

B. Functional reach test. It is a balance test to measure balance in standing position [20]. The participant was asked to assume standing position with barefoot with his arm stretched parallel to the wall and the shoulder joint was flexed to 90°. Then, the participant was asked to make a maximum forward inclination of the torso, with his upper limb reaching as far as possible without removing the heels from the floor and the distance in centimeters between the initial position and the final displacement from the trunk to the tip of the middle finger is the functional reach of the participant [21].

C. The Timed "Up and Go" (TUG): The time taken for the participant to rise from a chair without arms, wearing his/her own shoes and using any usual assistive devices (none, cane, or walker) was recorded. The participant was asked to walk a distance of three meters, make a 180º turn, and return to sit on the same chair. Timing started when the participant's back moved away from the chair and ends when the back touched the chair again [22,23].

Statistical analysis

Mean values of BBS, FRT and TUG of both groups were compared using Independent "t" test ($P<0.05$). Pearson's correlation coefficient (r) was applied to detect the degree of correlation between degree of diabetic peripheral neuropathy and BBS, FRT & TUG.

Results

Demographic data

Table (1) summarizes the comparison between diabetic patients without PN (DM) and with PN (DPN). DPN patients showed significantly higher duration of diabetes, serum glucose, glycosylated hemoglobin (HbA1c) and serum insulin in comparison to diabetic patients without PN.

The mean values of BBS, FRT and TUG were significantly decreased in DPN patients. Also; there were significant differences between both groups (Table 2). The Pearson's correlation coefficients test for the relationship between the degree of peripheral neuropathy and BBS and FRT scores showed a strong inverse relationship, while there was a strong direct relationship between the degree of peripheral neuropathy and TUG (Table 3).

TABLE 1: THE SUBJECT CHARACTERISTICS FOR ALL PARTICIPANTS.

	Mean ±SD			
Characteristic	**Group (A)**	**Group (B)**	**T-value**	***p-value***
Age (y)	48.32 ± 2.75	46.71 ± 3.82	1.21	>0.05
Height (cm)	173.15 ± 3.35	172.45 ± 2.87	1.41	>0.05
Weight (kg)	96.22 ± 6.86	94.83 ± 7.14	1.68	>0.05
BMI (kg/m^2)	31.43 ± 1.92	32.62 ± 1.76	1.93	>0.05
Gender (M /F)	79/21	18/82	1.87	>0.05
Duration of diabetes	7.41 ± 1.16	11.83 ± 2.14*	3.96	<0.05
SBP (mm Hg)	135.11 ± 5.41	133.27 ± 4.66	1.94	>0.05
DBP (mm Hg)	85.83 ± 3.81	87.16 ± 3.52	1.76	>0.05
Glucose (mmol/l)	6.12 ± 0.64	7.48 ± 0.79*	4.12	<0.05
HbA1c (%)	5.11 ± 0.51	7.15 ± 0.83*	3.86	<0.05
Insulin (µU/ml)	9.12 ± 1.97	14.82 ± 2.57*	3.42	<0.05
Cholesterol (mmol/l)	4.96 ± 0.34	4.74 ± 0.32	1.04	>0.05
HDL-C (mmol/l)	1.54 ± 0.28	1.63 ± 0.26	1.13	>0.05
LDL-C (mmol/l)	2.74 ± 0.21	2.61 ± 0.25	1.08	>0.05
Triglyceride (mmol/l)	2.23 ± 0.72	2.11 ± 0.61	1.12	>0.05

BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HBA1c: glycosylated hemoglobin; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; (*) indicates a significant difference between the two groups, P < 0.05.

Table 2: Mean values of BBS, FRT and TUG of group (A) and group (B).

	Mean ±SD			
	Group (A)	**Group (B)**	**T-value**	***p-value***
Berg Balance Scale (overall)	55.73 ± 2.15	49.81 ± 1.94	6.87	< 0.0
Functional Reach Test (cm)	46.92 ± 2.31	40.17 ± 2.28	5.63	< 0.0
The Timed "Up and Go" (sec)	9.17 ± 1.32	12.85 ± 1.63	5.32	< 0.0

FRT: Functional Reach Test; GUG: Timed Get Up Go Test; BBS: Berg Balance Scale.

TABLE 3: PEARSON'S CORRELATION COEFFICIENT BETWEEN DEGREE OF PERIPHERAL NEUROPATHY AND BBS, FRT& TUG SCORES IN PATIENTS WITH DPN.

Balance test	**Degree of peripheral neuropathy**
Berg Balance Scale (overall)	0.658*-
Functional Reach Test (cm)	0.791 **-
The Timed "Up and Go" (sec)	0.682*-

Spearman's correlation was used *: P < 0.05 **: P < 0.01

Discussion

The present study was to evaluate the risk of fall among the diabetic Saudi patients without peripheral neuropathy. Overall, our results confirmed that participants with DPN had lower scores of balance performance measured by BBS, FRT and TUG. These results were in line with many previous studies.

Many studies proved that there is a deficit in postural control among patients with DPN using platform and posturography systems in measuring postural sway properties [24-25]. While Ghanavati and colleagues confirmed patients with DPN total score of BBS test was significantly lower than their healthy control subjects [26]. However, Resnick et al. (2002) found that diabetic subjects with PDN had significantly worse dynamic and static balance and coordination relative to non-diabetic subjects [27, 28]. However, Lord et al. (1999) stated that strength of the antigravity muscles of lower limbs was weak among patients with DPN [29]. Also, Ozdirenc et al. (2003) reported that elderly subjects either older adults with or without DPN had reduced walking speed and balance performance [30].

Turcot and colleagues (2009) conducted the first study to investigate the balance instability of 24 diabetic patients using accelerometers; their results confirmed that diabetic patients with peripheral neuropathy had greater postural instability with higher acceleration values than healthy subjects and diabetic patients without peripheral neuropathy [31]. However, Cimbiz and Cakir (2005) proved that investigation of standing on dominant and non-dominant leg, functional reach and physical fitness tests revealed that all of these measures were lower in Type 2 diabetic neuropathic patients than healthy control subjects [32]. Also, Lim and colleagues (2005) proved that functional limitations and dynamic balance instability were more noticeable among diabetic patients with peripheral neuropathy than healthy subjects and diabetic patients without peripheral neuropathy [33].

Regarding Pearson's correlation coefficient between degree of peripheral neuropathy and BBS, FRT& TUG scores in patients with DPN, our results confirmed that there was a strong direct relationship between TUG and the severity of DPN. However, there was a strong inverse relationship between BBS& FRT and the severity of DPN. These findings are similar to finding of Lafond et al. (2004) [34] and Boucher et al. (1995) [35] stated that

the score of BBS was significantly reduced as the severity DPN increased.

The possible mechanism of the balance deficit among PND may be due to decline of sensory function since many everyday balance and walking activities require optimal sensory and proprioceptive input to be performed successfully [36]. Impaired balance may be related to DPN somatosensory deficit that include loss of lower limb muscle spindle function, ankle joint movement perception and plantar cutaneous sensation [37, 38]. Consequently, the loss of appropriate sensory input related to neuropathy impacts everyday movements and has been directly linked to increased incidence of falls [39-41].

Conclusion

Diabetic patients with peripheral neuropathy had more balance deficit than diabetic patients without peripheral neuropathy.

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This study was conducted without external financial support.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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خلل التوازن بين مرضى السكري السعوديين

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المستخلص:

الخلفية: حاليا خطر السقوط مرتفع بين مرضى السكري في المملكة العربية السعودية. في الوقت الحاضر، ينصب الاهتمام مباشرة على الوقاية من السقوط من خلال الدراسات البحثية المستقبلية التي تحاول تقليل مخاطر السقوط. **الهدف:** كانت الدراسة الحالية تهدف إلى الكشف عن حدوث السقوط بين مرضى السكري السعوديين المصابين باعتلال الأعصاب المتعددة. **المواد والطرق:** تم تقسيم مائتي مريض سعودي مصاب بداء السكري من النوع 2، تراوحت أعمارهم بين 40 و 55 عامًا، إلى مجموعتين: مرضى السكري والذين يعانون من اعتلال الأعصاب المحيطية الراسخ (مجموعة الاعتلال العصبي المحيطي السكري) الذين تم تشخيص مرض السكري لهم من خلال الإرشادات السريرية وتم تقييم أداء التوازن باستخدام اختبار الوصول الوظيفي(FRT) ، واختبار المتابعة الموقوتة (TUG) ومقياس بيرج للتوازن .(BBS). **النتائج:** تم اكتشاف اختلافات معنوية بين المجموعات لمرض BBS و FRT والتي كانت أقل بشكل ملحوظ لمرضى السكري الذين يعانون من اعتلال الأعصاب المحيطية مقارنة بمرضى السكري. بينما ، تم الكشف أيضا عن قيم أعلى معنوية لمرضى السكري الذين يعانون من اعتلال الأعصاب المحيطي ل TUG مقارنة بمرضى السكري. **الخلاصة:** نقدم دليلا على أن مرضى السكري الذين يعانون من اعتلال الأعصاب المحيطية يعانون من عجز أكبر في التوازن مقارنة بمرضى السكري الذين لا يعانون من اعتلال الأعصاب المحيطية.

الكلمات الدالة: التوازن. نوع 2 داء السكري; الاعتلال العصبي المحيطي السكري.

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Original Article

Bone turnover markers response to aerobic versus resistance exercise among postmenopausal Saudi women

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Abstract:

BACKGROUND: Menopause is characterized by low bone turnover biomarkers (BTMs), leading to a faster reduction in bone mass and an increased risk of fractures. Osteoporosis is a major health concern among postmenopausal women in Asia. Physical exercise is widely recognized as an effective method for both the primary and secondary prevention of osteoporosis-related fractures. However, our understanding of the most effective exercise training program to prevent osteoporosis in postmenopausal women remains incomplete. **OBJECTIVE**: The present study was designed to examine the effects of aerobic versus resisted exercise training on markers of bone turnover in postmenopausal Saudi women, including serum osteoprotegerin (OPG), receptor activator of nuclear factor kappa B ligand (RANKL), and the OPG/RANKL ratio. **MATERIALS and METHODS:** One hundred Saudi postmenopausal women, aged 50 to 58 years, participated in the study. Participants enrolled in two groups: Group (A) received treadmill aerobic exercises where, group (B) received resistance exercise training for 6 months. **RESULTS:** There were significant improvement in six-minute walking test and hand grip strength and significant reduction in serum osteoprotegerin (OPG), receptor activator of nuclear factor kappa B ligand (RANKL) and OPG/receptor activator of nuclear factor kappa B ligand (OPG/ RANKL) ratio in group A compared to group B. **CONCLUSION:** Six months of resisted exercise is superior to aerobic exercise in modifying bone turnover markers and functional ability among postmenopausal women.

Keywords: Aerobic Exercise; Bone Turnover Markers; Resistance Exercise; Menopause.

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Introduction

Menopause is characterized with low bone turnover biomarkers (BTMs), leading to faster reduction of bone mass and higher fracture risk [1,2]. Among Asian subjects, osteoporosis is a common medical problem as it is expected to cause about 50% of hip fractures among Asian population in 2050 [3]. Reduction in bone mass and strength leads to an increased risk of fractures [4]. Bone mineral density (BMD) is the usual method for measuring bone strength [4,5] which gradually reduced from the 4th decade and accelerates in early years of postmenopausal period [6–8]. This increases the risk of fracture especially spinal, forearm and hip fractures [4,9]. Approximately 200 million women worldwide have osteoporosis [9], and about 6% of men and 21% of women in Western countries suffer from osteoporosis [4].

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Bone turnover biomarkers (BTMs) refers to resorption and formation of bone which reflect the remodeling status of bones [10]. Diabetes mellitus adversely affects remodeling of bone as biomarkers of both bone resorption and formation are reduced [11-14]. Despite increased bone marrow density, diabetic patients suffer from high fracture risk [15,16]. Therefore, BTMs are considered more sensitive than BMD in determining the fracture risk in diabetic patients [17,18].

Bone turnover biomarkers (BTMs) can be considered as possible osteoporosis predictors [19-24] and a measure for hip fracture risk [25-27]. Independent of BMD, several studies considered BTMs as predictors for fractures [21, 28,29].

Physical exercise is an accepted method for both primary and secondary prevention of fractures related to osteoporosis [4,9]. Aerobic walking exercise can improve bone density and as a result reduce fracture risk [30-34]. Previous studies proved that different exercise programs positively affect bone density among postmenopausal women [4-7].

Decreased bone density, abnormal bone metabolism, and reduced muscle strength can be improved through aerobic and resisted exercise training. Therefore, the present study was designed to examine the effects of aerobic versus resisted exercise training on markers of bone turnover in postmenopausal Saudi women after 6 months.

Materials and Methods

Subjects

One hundred postmenopausal Saudi women aged 50-58 years. The inclusion criteria were: menopause onset more than 10 years ago, non-smokers, no alcohol consumption, and no use of hormone replacement therapy. The exclusion criteria included diabetes, hypertension, cardiac, musculoskeletal, or endocrine disorders, as well as the use of medications that may affect bone metabolism. All participants signed the consent form prior to their participation. Participants were divided into two groups. Group A received treadmill exercise training, while Group B received resisted exercise training.

Measurements

A**. Bone turnover biochemical markers measurement:** Overnight fasting venous blood samples were collected, centrifuged, and stored at -70°C to measure bone turnover and bone resorption biomarkers. These included serum osteoprotegerin (OPG) and receptor activator of nuclear factor kappa B ligand (RANKL), which were determined using commercial sandwich enzyme-linked immunosorbent assays (ELISA) according to the manufacturers' protocols (Immunodiagnostic Systems Ltd, Boldon, UK and Cusabio Biotech, China). The same serum samples used for RANKL measurements were also used for OPG measurements, and the assay was performed blinded to the subject group [35].

B. Hand Grip Strength: Hand dynamometer (Jamar, Sammons Preston Rolyan, Cedarburg, WI, USA) was used in assessment of grip strength. The mean value of two measurement trials was taken, with the elbow joint flexed at a right angle and without any part of the body in close contact [36].

C. Six Minute Walk Test (6MWT): The mean distance walked by each participant within 6 minutes in two different days was analyzed [37].

All assessments of handgrip strength, the six-minute walk test, OPG, RANKL, and the OPG/RANKL ratio were taken before the start of the training program and after its completion.

Procedures

All participants were randomly enrolled in two equal groups as following:

Group (A): Training program included range of motion and stretching exercises as a warming–up for five minutes, treadmill aerobic exercise for 30 minutes and 10 minutes of cooling down. Participants completed a 6-months treadmill aerobic exercise, three sessions weekly [38].

Group (B): The training program included resistance exercises on various resistance machines, with three sessions per week for 6 months. The program consisted of a 5-minute warm-up with range of motion and stretching exercises, followed by 30 minutes of resistance training targeting the upper limbs, lower limbs, and trunk muscles, and concluding with a 10-minute cool-down [39].

Statistical analysis

The mean values of the investigated parameters obtained before and after six months in both groups were compared using paired "t" test. Independent "t" test was used for the comparison between the two groups ($P<0.05$).

Results

Table 1 shows the baseline characteristics of the participants who entered the trial. There were no significant differences in baseline characteristics between the two groups.

TABLE 4: BASELINE AND DEMOGRAPHIC CHARACTERISTICS OF STUDY PARTICIPANTS.

Characteristic	Group (A)	Group (B)	*p*-value
Age (years)	56.64 ± 4.27	57.21± 5.36	> 0.05
BMI (kg/m^2)	23.82 ± 4.54	24.37± 4.18	> 0.05
SBP (mm Hg)	131.46 ± 9.25	132.15 ± 8.39	> 0.05
DBP (mm Hg)	84.62 ± 6.12	86.24 ± 4.55	> 0.05
BMD of lumber spine (mg/cm)	127.28 ± 8.54	125.79 ± 8.11	> 0.05
BMD of tibia (mg/cm)	266.18 ± 10.67	263.94 ± 11.24	> 0.05
BMD of radius (mg/cm)	270.76 ± 10.42	268.34 ± 9.23	> 0.05
Serum Calcium (mg/dl)	8.53 ± 2.23	8.26 ± 2.12	> 0.05
Parathyroid Hormone (pg/ml)	13.74 ± 3.12	14.29 ± 3.25	> 0.05

BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

The mean values of six-minute walking test and hand grip strength were significantly increased, while the mean values of the serum osteoprotegerin (OPG), receptor activator of nuclear factor kappa B ligand (RANKL) and OPG/receptor activator of nuclear factor kappa B ligand (OPG/ RANKL) ratio were significantly decreased in the both groups at the end of the study (table 2 and 3). Additionally, there were significant differences between the mean levels of the investigated parameters in Group A and Group B at the end of the study, with greater changes observed in patients who received resisted exercise training (tables 4). These results confirm that resisted exercise is more effective than aerobic exercise training in modulating bone turnover markers and improving functional ability in postmenopausal women.

Discussion

Changes in the musculoskeletal system following menopause are significant health concerns due to their serious complications, which increase morbidity and mortality among affected individuals. Decreased bone density, abnormal bone metabolism and decreased general muscle strength can be corrected by aerobic and resisted exercise training. Therefore, the present study was designed to evaluate the effects of aerobic versus resisted exercise training on bone turnover markers in postmenopausal Saudi women over a 6-month period. Our principal finding in the present study was that six months of resisted exercise is more effective than aerobic exercise in modifying bone turnover markers and enhancing functional ability among postmenopausal women. These findings are consistent with previous research.

TABLE 5:MEAN VALUE AND SIGNIFICANCE OF HANDGRIP STRENGTH, SIX-MINUTE WALK TEST, OPG, RANKL AND OPG/RANKL OF GROUP (A) BEFORE AND AT THE END OF THE STUDY.

	Mean +SD		T-value	*p*-value
	Pre	Post		
Hand grip strength (mmHg)	149.31 ± 17.27*	170.54 ± 19.28	3.42	< 0.05
Six minute walk test (meter)	322.53 ± 24.64*	381.41 ± 28.13	3.77	< 0.05
OPG (pg/mL)	507.16 ± 35.83*	462.25 ± 32.42	4.18	< 0.05
RANKL (pg/mL)	28.17 ± 7.94*	25.33 ± 6.21	3.26	< 0.05
OPG/ RANKL	29.23 ± 9.15*	23.82 ± 8.16	3.34	< 0.05

OPG: Serum osteoprotegerin; RANKL: Receptor activator of nuclear factor kappa B ligand; (*) indicates a significant difference, P < 0.05.

TABLE 6: MEAN VALUE AND SIGNIFICANCE OF HANDGRIP STRENGTH, SIX-MINUTE WALK TEST, OPG, RANKL AND OPG/RANKL OF GROUP (B) BEFORE AND AT THE END OF THE STUDY.

	Mean +SD		T-value	*p*-value
	Pre	Post		
Hand grip strength (mmHg)	147.25 ± 18.91*	193.61 ± 21.43	7.38	< 0.05
Six minute walk test (meter)	318.24 ± 26.12*	436.17 ± 30.29	8.45	< 0.05
OPG (pg/mL)	512.55 ± 38.74*	423.42 ± 31.65	9.16	< 0.05
RANKL (pg/mL)	29.32 ± 8.11*	22.85 ± 6.73	6.57	< 0.05
OPG/ RANKL	30.56 ± 9.63*	19.71 ± 7.82	7.14	< 0.05

OPG: Serum osteoprotegerin; RANKL: Receptor activator of nuclear factor kappa B ligand; (*) indicates a significant difference, P < 0.05.

TABLE 7: MEAN VALUE AND SIGNIFICANCE OF HANDGRIP STRENGTH, SIX-MINUTE WALK TEST, OPG, RANKL AND OPG/RANKL OF GROUP (A) AND GROUP (B) AT THE END OF THE STUDY.

	Mean +SD		T-value	*p*-value
	Group (A)	Group (B)		
Hand grip strength (mmHg)	170.54 ± 19.28*	193.61 ± 21.43	3.22	< 0.05
Six minute walk test (meter)	381.41 ± 28.13*	436.17 ± 30.29	3.45	< 0.05
OPG (pg/mL)	462.25 ± 32.42*	423.42 ± 31.65	4.23	< 0.05
RANKL (pg/mL)	25.33 ± 6.21*	22.85 ± 6.73	3.39	< 0.05
OPG/ RANKL	23.82 ± 8.16*	19.71 ± 7.82	3.43	< 0.05

OPG: Serum osteoprotegerin; RANKL: Receptor activator of nuclear factor kappa B ligand; (*) indicates a significant difference, P < 0.05.

Our findings confirmed that both resisted and aerobic exercises significantly improved patients' functional ability with greater significant results in the resisted exercise training group. Schmitt et al. (2009) reported that two prospective cohort studies demonstrated a negative relationship between hip fracture risk and physical activity, as evidenced by a slowing of bone loss and improved bone density associated with physical activity in postmenopausal women [40]. Similarly, another study that implemented a combined aerobic and resisted exercise training program over 12 months found a reduction in the rate of bone loss, along with improvements in maximum isometric strength in postmenopausal women [41]. Moreover, Küçükçakır et al. (2013) demonstrated that Pilates exercises, performed twice a week for 12 months, are an effective and safe alternative treatment for improving quality of life and functional status in postmenopausal women with osteoporosis [42]. Marques et al. (2013) conducted a study with forty-seven healthy older adults who engaged in resistance and weight-bearing exercises. The findings demonstrated that exercise training significantly improved bone mineral density (BMD), lower limb strength, balance performance, and modulated inflammatory biomarkers [43].

In the present study, both six months of resisted and aerobic exercise training significantly increased serum osteoprotegerin (OPG) levels and the OPG/RANKL ratio, while also reducing serum RANKL levels, with more pronounced changes observed following the resisted exercise training program. These results agreed with Kim et al. (2006) who stated that mechanical stimulation inhibits osteoclastogenesis that resulted from dynamic flow-induced shear stress through increased level of OPG and reduced levels of RANKL [44]. Similarly, Saunders et al. (2006) reported increased levels of OPG following mechanical stimulation through substrate deformation [45]. However, more intense training via long-distance running significantly improved values of BMD [46]. Esen et al. (2009) proved that ten weeks of high intensity walking training program resulted in significant reduction in the level of RANKL in middle-aged men [47]. However, Marques et al. (2013) reported that both aerobic and resisted exercise training had little effect on bone metabolism markers included RANKL and OPG [43]. Conversely, Marques et al. (2011) reported that muscle strength and BMD, along with OPG and RANKL levels, significantly improved after 8 months of resistance exercise, showing more favorable changes compared to aerobic exercise [48].

Conclusion

Six months of resisted exercise is superior to aerobic exercise in modifying bone turnover markers and functional ability among postmenopausal women.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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استجابة علامات دوران العظام للتمارين الهوائية مقابل التمارين المقاومة بين النساء السعوديات بعد انقطاع الطمث

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المستخلص:

الخلفية: يتميز انقطاع الطمث بانخفاض المؤشرات الحيوية لدوران العظام (BTMs) مع تقليل أسرع في كتلة العظام وارتفاع خطر الكسر. تعتبر هشاشة العظام مشكلة صحية رئيسية بين النساء الآسيويات بعد انقطاع الطمث. التمرين البدني هو وسيلة مقبولة في كل من الوقاية الأولية والثانوية من الكسور المرتبطة بهشاشة العظام. ومع ذلك، فإن فهمنا لأفضل برنامج تدريبي للوقاية من هشاشة العظام بين النساء بعد انقطاع الطمث غير مكتمل. **الهدف:** تم تصميم الدراسة الحالية لفحص تأثيرات التدريب الهوائي مقابل التدريب المقاوم على علامات دوران العظام لدى النساء السعوديات بعد انقطاع الطمث، والتي تشمل أوستيوبروتيجيرين (OPG) في المصل، ومنشط مستقبلات العامل النووي كابا ب(RANKL) ، ونسبة/OPG منشط مستقبلات العامل النووي كابا ب .(OPG/RANKL) **المواد والأساليب:** مائة امرأة سعودية بعد انقطاع الطمث، تتراوح أعمارهن بين 50-58 عامًا. تم تسجيل المشاركين في مجموعتين: المجموعة (أ) تلقت تمارين هوائية على جهاز المشي حيث تلقت المجموعة (ب) تدريبات على تمارين المقاومة لمدة 6 أشهر. **النتائج:** كان هناك تحسن معنوي في اختبار المشي لمدة ست دقائق وقوة قبضة اليد وانخفاض معنوي في مصل أوستيوبروتيجيرين (OPG) ، ومنشط مستقبلات العامل النووي كابا ب (RANKL) و / OPG منشط المستقبل للعامل النووي كابا ب (OPG / RANKL) نسبة الترابط الناتج عن العامل النووي كابا ب / OPG) (RANKL بعد التدريب في كلتا المجموعتين مع وجود فروق ذات دلالة إحصائية بين المجموعتين. **الخلاصة:** ستة أشهر من التمارين المقاومة تتفوق على التمارين الهوائية في تعديل علامات دوران العظام والقدرة الوظيفية لدى النساء بعد انقطاع الطمث.

الكلمات الدالة: التمارين الهوائية. علامات دوران العظام. تمرين المقاومة. سن اليأس.

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Original Article

Coagulation, fibrinolytic parameters and cytokines response to weight reduction in obese Saudi women

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Abstract:

BACKGROUND: Obesity is a relevant risk factor for major cardiovascular events due to the atherosclerotic involvement of coronary, cerebral and lower limb arterial vessels. A major role in the increased cardiovascular risk is played by platelets, which show an increased activation and a reduced sensitivity to the physiological and pharmacological anti-aggregating agents. However, no studies have compared the effects of simple calorie restriction with those of calorie restriction combined with aerobic exercise on fibrinolytic and coagulative factors, as well as cytokine levels. **OBJECTIVE**: The aim of this study was to investigate the effect of weight reduction on the fibrinolytic, coagulative factors and cytokines in obese Saudi women. **MATERIALS and METHODS:** One hundred obese Saudi women participated in this study and were included into two equal groups. The first group (A) received physical training combined with dietary measures, three sessions per week for three months. The second group (B) maintained their baseline lifestyle without additional interventions. Measurements of body mass index (BMI), Fibrinogen, von Willbrand factor (vWF-Ag) antigen, plasminogen activator inhibitor-1 activity (PAI-1:Ac) and antigen (PAI-1:Ag) & prothrombin time (PT), partial thromboplastin time (PTT), tissue plasminogen activator activity (tPA:Ac) , antigen (tPA:Ag) , tumor necrotic factor - alpha (TNF-α), interleukin–6 (IL-6) and leptin were done before the study and after three weeks at the end of the study. **RESULTS:** The results of this study indicated a significant decrease in BMI, Fibrinogen, vWF-Ag, PAI-1:Ac and PAI-1:Ag & PT, PTT, tPA:Ac, tPA:Ag ,TNF-α, IL-6 and leptin in group (A), while these changes were not significant in group (B). **CONCLUSION:** Weight reduction modulates Coagulation, fibrinolytic parameters and cytokines in obese Saudi women.

Keywords: Obesity; inflammatory cytokines; Coagulation; fibrinolytic parameters.

Introduction

Obesity is a relevant risk factor for major cardiovascular events due to the atherosclerotic involvement of coronary, cerebral and lower limb arterial vessels. A major role in the increased cardiovascular risk is played by platelets, which show an increased activation and a reduced sensitivity to the physiological and pharmacological anti-aggregating agents [1].

Obesity is independently associated with an elevated risk of cardiovascular morbidity and mortality due to atherothrombotic events [2]. The susceptibility to the clinical manifestations of atherosclerosis is related to the presence of low grade inflammation together with the variable co-existence of impaired glucose metabolism atherogenic

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dyslipidemia, arterial hypertension, endothelial dysfunction and a prothrombotic state [3,4].

Mean platelet volume, a parameter closely associated with in vivo platelet activation [5], has been reported to be elevated in patients with obesity [6, 7]. Obese women also show an increase in platelet count [8]. Interleukin-6 (IL-6) induces a modest increase in platelet count and enhances platelet size and function, likely through its action at the megakaryocyte level [9], whereas Tumor necrosis factor- α (TNF-α) increases platelet adhesion to endothelial cells [10]. Despite the significant advancements in understanding the pathogenesis and treatment of atherothrombosis associated with obesity, coronary heart disease is projected to be the leading cause of mortality worldwide by 2020 [11].

Obesity is associated with reduced adipose tissue oxygenation, hypoxia, and increased chemotaxis of inflammatory cells [12]. Monocytes are recruited to adipose tissue, where they secrete tumor necrosis factor-alpha (TNF-α) and interleukin-6 [13], along with leptin and resistin produced by dysfunctional adipocytes [14].
Regular physical activity seems to induce improvement in fibrinolytic activity, as indicated by an increase in t-PA activity and a decrease in PAI-1 activity [15]. Exercise at moderate intensity may also suppress platelet activation and polymorphonuclear leukocyte interaction with surface-adherent platelets under shear flow. Also, weight reduction may reduce the risk of CVD [16].

Fibrinolytic activity on postmenopausal women could be improved by a 3-week regular submaximal training program. These changes on the hemostatic factors suggest that short-term aerobic training may prevent the decline in fibrinolytic function observed in sedentary postmenopausal women [17].

The presence of a prothrombotic state accounts in part for the high prevalence of cardiovascular events in obese subjects [18]. Weight reduction contributes to a decrease in CVD-related morbidity through improvement of fibrinolytic abnormality and endothelial dysfunction [19]. Dietary therapy, physical activity and combination therapy (diet and physical activity) have been adopted as weight reduction regimens [20]. The aim of this study was to investigate the effect of weight reduction on the fibrinolytic, coagulative factors and cytokines in obese subjects.

Materials and Methods

Subjects

One hundred obese Saudi women were selected from the Internal Medicine Department at King Abdulaziz University Hospital and other hospitals in the Jeddah area. Their ages ranged from 35 to 45 years, and their body mass index (BMI) ranged from 32 to 36 kg/m². The exclusion criteria included smoking; the use of prescribed medications, including regular aspirin and non-steroidal anti-inflammatory drugs (NSAIDs); hypertension; diabetes; a personal history of cardiovascular disease (CVD); thyroid disease; and orthopedic issues that could inhibit treadmill training. Informed consent was obtained from all participants.

Participants were divided into two equal groups. Group A received physical training combined with dietary interventions, with three sessions per week over the course of three months. Group B maintained their baseline lifestyle without any additional interventions. This study was approved by the Scientific Research Ethical Committee, Faculty of Applied Sciences, King Abdulaziz University. Informed consent was obtained from all participants. All participants were free to withdraw from the study at any time.

Equipment

1. Treadmill (Enraf Nonium, Model display panel Standard, NR 1475.801, Holland) was used in performance of aerobic walking exercise.

2. Plasma vWF was measured by commercial Enzyme Linked Immuno Sorbent Assay (ELISA) method (Zymutest vWF, Hyphen Biomed, Neuville sur Oise, France). PT and PTT were determined using (Tromboplastin D, Fisher Diagnostics, Middletown, USA) and (APTT-XL, Fisher Diagnostics, Middeltown, USA). tPA and PAI-1 activities and antigens were determined using the Imulyse™ enzyme-linked immunosorbent assay (ELISA) kits (Biopool, Umea, Sweden) and the activities using Chromolize™ tPA and Spectrolyse® pL PAI (Biopool, Umea, Sweden) in accordance with the manufacturer's instructions. While IL-6 level was measured using "Immulite 2000" immunassay analyzer (Siemens Healthcare Diagnostics, Deerfield, USA). However, TNF-α level was analyzed with ELISA kits using ELISA microplate strip washer (ELX 50), and ELISA microplate reader (ELX 808; BioTek Instruments, USA). Also, plasma samples with K2EDTA were collected after centrifugation (2000 × g for 10 min at 4°C) and stored at −80°C to analyze leptin. All analyses were carried out on a Hitachi 7170 Autoanalyser (Tokyo, Japan) or with commercial kits (Randox).

3. Weight and height scale (JENIX DS 102, Dongsang, South Korea) was used to measure weight and height to calculate the body mass index (BMI).

Measurements

1. Laboratory analysis: Blood samples were collected from the antecubital vein at the beginning and end of the treatment program. After a 12-hour fast, blood samples were drawn from subjects at the same time each morning, between 8 and 10 AM. Subjects were instructed to lie supine for 10 minutes prior to blood collection. A 10 mL blood sample was drawn into a tube containing 0.1 M sodium citrate. Blood was centrifuged at 2000 ×g for 10 min at 4 °C and stored at − 80 °C until analysis. Plasma vWF, PT, PTT, TPA and PAI-1 were measured in accordance with the manufacturer's instructions. All standards and samples were measured in duplicate and all samples from the one subject were measured on the same plate; Fibrinogen was measured by the time titration method employing the ST-4 coagulation instrument (Zymutest Fibrinogen, ELISA, Hyphen Biomed, Neuville sur Oise, France). While, IL-6 and TNF-α levels were analyzed with ELISA kits using ELISA microplate strip washer, and ELISA microplate reader. Also, plasma sample with K2EDTA was collected after centrifugation (2000 × g for 10 min at 4°C) and stored at −80°C to analyze leptin [21].

2. Evaluation of anthropometric parameters: All measurements were taken at baseline and after three months, at the conclusion of the study. Participants were measured while wearing undergarments and hospital gowns. Height was recorded using a digital stadiometer (JENIX DS 102, Dongsang, South Korea) to the nearest 0.1 cm. Body weight was measured on a calibrated balance scale to the nearest 0.1 kg (HC4211, Cas Korea, South Korea), and BMI was calculated using the formula: BMI = Body weight / (Height)². All measurements of BMI, PT, PTT, tPA:Ac , tPA:Ag, fibrinogen, vWF-Ag, PAI-1:Ac ,PAI-1:Ag, TNF-α, IL-6 and leptin were taken before the starting of the study and after three months.

Procedures of the study

Following the initial evaluation, all participants were randomly assigned to the following groups:

1. Group (A) : Participants underwent a 40-minute aerobic session on a treadmill (Enraf Nonium, Model Display Panel Standard, NR 1475.801, Netherlands). The session began with a 5-minute warm-up phase at a low load, followed by 30 minutes of walking or running, depending on heart rate, with intensity set at 65%-75% of the maximum heart rate (HRmax) according to a modified Bruce protocol. The session concluded with a 5-minute recovery and relaxation phase. The target heart rate was based on the guidelines of the American College of Sports Medicine. All participants completed three sessions per week, totaling 36 sessions over a 3-month period. Additionally, a prescribed low-calorie diet, providing 1,200 kilocalories per day, was provided to all participants throughout the study's duration. The prescribed diet included a breakfast consisting of 2 boiled eggs (80 calories), 50 g of cheese (100 calories), and one piece of bread (105 calories). Lunch included 2 pieces of boiled meat (100 g, 240 calories) or chicken (300 calories), 500 g of salad (105 calories), 300 g of boiled vegetables (110 calories), and one banana (100 calories). Dinner consisted of 200 g of light milk (120 calories)

2. Group (B): Participants were instructed to maintain their usual lifestyle without any additional interventions for a period of 3 months

Statistical analysis

A paired t-test was used to compare the pre-test and post-test values of the investigated parameters within each group, while an unpaired t-test was employed to compare the results between the two groups ($p<0.05$).

Results

The mean values of BMI, fibrinogen, vWF-Ag antigen, PAI-1:Ac, and PAI-1:Ag were significantly decreased in Group A, while the mean values of PT, PTT, tPA:Ac, and tPA:Ag were significantly increased . Conversely, the results for Group B, which did not receive any treatment intervention, were not statistically significant (Tables 1 and 2). Moreover, significant differences were observed between the mean levels of the investigated parameters in Group A and Group B following the intervention (Table 3) ($p<0.5$).

TABLE 8: MEAN VALUE AND SIGNIFICANCE OF THE PRE AND POSTTEST VALUES OF BMI, PT, PTT, TPA:AC AND TPA:AG FIBRINOGEN, VWF-AG, PAI-1:AC AND PAI-1:AG IN THE TRAINING GROUP.

	Mean ± SD		t-value	*p*-value
	Pre	Post		
BMI (Kg / m^2)	36.17 ± 6.52	28.25 ±5.20	6.34	<0.05
PT (s)	10.5 ± 0.54	12.13 ± 0.98	5.17	<0.05
PTT (s)	21.82 ± 2.78	25.36 ± 2.82	5.85	<0.05
tPA:Ac (IU/mL)	5.12 ± 0.23	6.7 ± 0.11	4.36	<0.05
tPA:Ag (ng/mL)	3.25 ± 0.41	4.67 ± 0.64	4.23	<0.05
Fibrinogen(mg/mL)	3.85 ± 0.61	2.16 ± 0.13	4.11	<0.05
vWF-Ag (%)	92.46 ± 10.77	74.56 ± 11.65	6.52	<0.05
PAI-1:Ac (AU/mL)	4.9 ± 0.38	3.06 ± 0.15	4.02	<0.05
PAI-1:Ag (ng/mL)	19.84 ± 2.24	10.53 ± 2.16	5.04	<0.05
TNF- α (pg/mL)	5.71± 1.76	4.22 ± 1.14	6.52	<0.05
IL-6 (pg/mL)	8.76 ± 2.32	5.34 ± 1.85	6.19	<0.05

BMI= Body Mass Index; PT= prothrombin time; PTT= partial thromboplastin time; tPA:Ac = tissue plasminogen activator activity ; tPA:Ag = tissue plasminogen activator antigen ; vWF-Ag = von Willbrand factor antigen; PAI-1:Ac = plasminogen activator inhibitor-1 activity; IL-6= Interleukin – 6; PAI-1:Ag = plasminogen activator inhibitor-1 antigen; TNF-α = tumor necrotic factor – alpha.

Table 9:Mean value and significance of the pre and posttest values of BMI, PT, PTT, tPA:Ac and tPA:Ag fibrinogen, vWF-Ag, PAI-1:Ac and PAI-1:Ag in the control group.

	Mean ± SD		t- value	*p*-value
	Pre	Post		
BMI (Kg / m^2)	35.98 ± 6.87	36.11 ± 6.22	0.81	>0.05
PT (s)	11.29 ± 0.88	11.53 ± 0.94	0.79	>0.05
PTT (s)	22.31 ± 3.26	23.45 ± 3.15	0.86	>0.05
tPA:Ac (IU/mL)	5.15 ± 0.67	5.76 ± 0.72	0.92	>0.05
tPA:Ag (ng/mL)	3.43 ± 0.54	3.75 ± 0.83	0.86	>0.05
Fibrinogen (mg/mL)	3.57 ± 0.81	3.32 ± 0.75	0.74	>0.05
vWF-Ag (%)	92.78 ± 11.25	91.54 ± 12.04	0.65	>0.05
PAI-1:Ac (AU/mL)	4.3 ± 0.47	4.01 ± 0.64	0.67	>0.05
PAI-1:Ag (ng/mL)	19.62 ± 2.33	19.35 ± 2.52	0.53	>0.05
TNF- α (pg/mL)	5.66± 1.45	5.87 ± 1.33	0.63	>0.05
IL-6 (pg/mL)	8.67 ± 2.01	8.82 ± 2.13	0.53	>0.05

BMI= Body Mass Index; PT= prothrombin time; PTT= partial thromboplastin time; tPA:Ac = tissue plasminogen activator activity ; tPA:Ag = tissue plasminogen activator antigen ; vWF-Ag = von Willbrand factor antigen; PAI-1:Ac = plasminogen activator inhibitor-1 activity; IL-6= Interleukin – 6; PAI-1:Ag = plasminogen activator inhibitor-1 antigen; TNF-α = tumor necrotic factor – alpha

Discussion

Abnormalities in coagulation and fibrinolysis may play an important role in the risk of cardiovascular event in obese subjects. Blood clotting and intravascular thrombus formation are important in the development of acute coronary thrombosis [22]. Plasma level of fibrinogen, PAI-1 activity and tPA antigen play a central role in the development of thrombosis and are associated with coronary heart disease [23]. We observed a significant reduction in fibrinogen following weight reduction, consistent with the findings of previous studies.

Weight reduction contributes to a decrease in CVD-related morbidity through improvement of fibrinolytic abnormality and endothelial dysfunction [21]. Dietary therapy, physical activity and combination therapy (diet and physical activity) have been adopted as weight reduction regimens [19]. In obese women, a successful program for weight loss was shown to reduce chronic inflammation, oxidative stress as well as persistent platelet activation [24]. A study conducted on individuals with central obesity reported that a dietary intervention program, resulting in a 10% reduction in initial body weight, effectively reversed platelet resistance to the anti-aggregatory effects of nitric oxide (NO), prostacyclin, and cyclic nucleotide [1]. Weight loss in obese patients can therefore be considered a very effective strategy to improve the platelet abnormalities linked to insulin resistance [1].

In the present study, after weight reduction, tPA activity and tPA antigen were increased and PAI-1 activity and antigen were decreased. Murakami et al. (2007) reported

Table 10: Mean value and significance of the posttest values BMI, PT, PTT, tPA:Ac and tPA:Ag fibrinogen, vWF-Ag, PAI-1:Ac and PAI-1:Ag in the training and control groups.

	Mean ± SD		t- value	*p*-value
	Training group	Control group		
BMI (Kg / m^2)	28.25 ±5.20	36.11 ± 6.22	5.20	<0.05
PT (s)	12.13 ± 0.98	11.53 ± 0.94	4.12	<0.05
PTT (s)	25.36 ± 2.82	23.45 ± 3.15	4.31	<0.05
tPA:Ac (IU/mL)	6.7 ± 0.11	5.76 ± 0.72	3.02	<0.05
tPA:Ag (ng/mL)	4.67 ± 0.64	3.75 ± 0.83	3.46	<0.05
Fibrinogen (mg/mL)	2.16 ± 0.13	3.32 ± 0.75	3.32	<0.05
vWF-Ag (%)	74.56 ± 11.65	91.54 ± 12.04	5.75	<0.05
PAI-1:Ac (AU/mL)	3.06 ± 0.15	4.01 ± 0.64	3.28	<0.05
PAI-1:Ag (ng/mL)	10.53 ± 2.16	19.35 ± 2.52	4.49	<0.05
TNF- α (pg/mL)	4.22 ± 1.14	5.87 ± 1.33	6.65	<0.05
IL-6 (pg/mL)	5.34 ± 1.85	8.82 ± 2.13	6.46	<0.05

BMI= Body Mass Index; PT= prothrombin time; PTT= partial thromboplastin time; tPA:Ac = tissue plasminogen activator activity ; tPA:Ag = tissue plasminogen activator antigen ; vWF-Ag = von Willbrand factor antigen; PAI-1:Ac = plasminogen activator inhibitor-1 activity; IL-6= Interleukin – 6; PAI-1:Ag = plasminogen activator inhibitor-1 antigen; TNF-α = tumor necrotic factor - alpha

that PAI-1 activity and t-PA antigen values positively correlated with BMI and fat tissue mass. These high values were reduced after weight reduction.

A significant positive correlation was observed between the percentage changes in BMI, waist circumference, and fat tissue mass and the changes in PAI-1 activity [15]. These associations were in line with data from previous weight reduction trials [23-25]. Consistent with previous findings, our study demonstrates that weight reduction facilitates fibrinolysis by upregulating tissue plasminogen activator (tPA) activity and downregulating plasminogen activator inhibitor-1 (PAI-1) activity.

The results of the current study regarding prothrombin time (PT) and partial thromboplastin time (PTT) are consistent with the findings of Piccone et al.(2005) and Stratton et al (1997) [26, 27]. However, the present investigation shows that there was a significant reduction of vWF. These results are in agreement with the results of Paton et al. (2004) [28]. Saenko et al. (1999) reported that it is possible that the active cool down results in an increase in hepatic blood flow and clearance of vWF-Ag [29].

The results of the current study regarding fibrinogen indicate that weight reduction led to a decrease in fibrinogen concentration. This finding is consistent with the study by DeSouza et al. (1998), which demonstrated that plasma fibrinogen concentrations are lower in physically active postmenopausal women compared to their sedentary counterparts, with age-related increases in fibrinogen levels being twice as pronounced in sedentary women [30]. It has been suggested that the favorable association between plasma fibrinogen levels and regular exercise are likely due to lower body fatness [31, 32].

The results of this study demonstrated a significant reduction in TNF-α, IL-6, and BMI in Group A, whereas no significant changes were observed in Group B. These findings suggest that weight reduction is an effective intervention for modulating inflammatory cytokines in obese individuals. This is consistent with the findings of Esposito et al. (2003), who reported that medical weight loss in obese women led to significant decreases in elevated levels of IL-6, IL-18, C-reactive protein, and insulin resistance, along with a significant increase in the anti-inflammatory adipokine, adiponectin [33]. Reinher et al. (2005) demonstrated that weight loss resulting from a combined diet, physical activity, and behavioral intervention led to a significant reduction in TNF-α levels [34]. Also, significant reductions in BMI, fat mass, IL-6 and leptin concentrations was achieved after only 3weeks following a diet and physical activity intervention [35]. Bladbjerg et al. (2010) confirmed that weight loss by dietary intervention or gastric banding modulates hemostasis parameters in obese patients [36].

Overall, these studies support the notion that weight loss is associated with improvements in coagulation and inflammation profiles, potentially reducing thrombotic risk. Furthermore, Lijnen et al. (2012) demonstrated that caloric restriction and significant weight loss in obese mice were associated with improved plasma coagulation profiles, as well as reduced oxidative stress and inflammation in adipose tissues [37].

Conclusion

Coagulation, fibrinolytic activity and inflammatory cytokines could be improved by weight reduction in obese Saudi women received aerobic exercise training in addition to diet regimen.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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استجابة التخثر ودلالات الإلتهاب لإنقاص الوزن لدى النساء السعوديات البدينات

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المستخلص:

الخلفية: السمنة هي عامل خطر ذي صلة بأمراض القلب والأوعية الدموية بسبب تصلب الشرايين في الأوعية الشريانية التاجية والدماغية. تلعب الصفائح الدموية دورا رئيسيا في زيادة مخاطر الإصابة بأمراض القلب والأوعية الدموية ، والتي تظهر زيادة التنشيط وانخفاض الحساسية للعوامل الفسيولوجية والدوائية المضادة للتجميع. ومع ذلك ، لم يتم إجراء أي دراسات لمقارنة آثار تقييد السعرات الحرارية البسيطة وآثار تقييد السعرات الحرارية جنبا إلى جنب مع التمارين الهوائية على عوامل التخثر ودلالات الإلتهاب. **الهدف:** تهدف هذه الدراسة إلى التحقيق في تأثير إنقاص الوزن على عوامل التخثر ودلالات الإلتهاب لدى النساء السعوديات البدينات. **المواد والأساليب:** شاركت في هذه الدراسة مائة امرأة سعودية تعاني من السمنة المفرطة ، وتم إدراجهن في مجموعتين متساويتين. تلقت المجموعة الأولى (أ) تدريبا بدنيا مقترنا بتدابير غذائية، ثلاث جلسات في الأسبوع لمدة ثلاثة أشهر. المجموعة الثانية (ب) لم تتلق أي تدخل علاجي. تم إجراء قياسات مؤشر كتلة الجسم عوامل التخثر ودلالات الإلتهاب قبل الدراسة وبعد ثلاثة أسابيع في نهاية الدراسة. **النتائج:** أشارت نتائج هذه الدراسة إلى انخفاض كبير في مؤشر كتلة الجسم، عوامل التخثر ودلالات الإلتهاب واللبتين في المجموعة الأولي، بينما لم تكن هذه التغيرات ذات دلالة إحصائية في المجموعة الثانية. **الخلاصة:** يعدل إنقاص الوزن عوامل التخثر ودلالات الإلتهاب لدى النساء السعوديات البدينات.

الكلمات الدالة: السمنة; عوامل التخثر ودلالات الإلتهاب.

الباحث الرئيسي:
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Case Report

Effects of an 8-Week Structured Physiotherapy Program on Health-Related Quality of Life and Walking Speed in a Child Following Rotationplasty: A Case Study

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Abstract:

Children undergoing rotationplasty for osteosarcoma frequently experience a combination of post-operative challenges, including muscle weakness and difficulties in gait. This case study aimed to evaluate the effects of an 8-week structured physiotherapy intervention on these functional limitations, as well as health-related quality of life, walking speed, and ankle joint range of motion (ROM) in a child prior to prosthetic fitting. A 12-year-old boy received rotationplasty for the treatment of left distal femoral osteosarcoma. A structured physiotherapy program was implemented, commencing immediately post-operatively and progressing through a series of stages tailored to the patient's evolving functional capacity. QE-5D-5L visual analogue scale (VAS) self-report, 10-meter walk test performance, and ankle joint ROM were assessed at baseline, 4 weeks, and 2 months post-physiotherapy intervention, representing key milestones in the pre-prosthetic rehabilitation phase, during which improvements in health-related quality of life, walking speed, and ankle joint ROM were assessed. Scores on the QE-5D-5L VAS increased from 94% to 99%, walking speed improved from 0.31 m/s to 0.83 m/s, ankle dorsiflexion range of motion (ROM) increased from -15° to 20°, and ankle plantarflexion ROM increased from 50° to 75°. These findings suggest that the early initiation of physiotherapy, which includes strengthening exercises, gait training, and balance activities, is effective in enhancing functional outcomes in pediatric patients following rotationplasty.

Keywords: Osteosarcoma; Physiotherapy; Health Status; Walking Speed; Rotationplasty

Introduction

Osteosarcoma is one of the most common cancer disease that appear among children, especially during puberty with unknown causes [1]. Usually, osteosarcoma occurs in the growth area of long bone [2]. Osteosarcoma is diagnosed clinically from the localized pain with range of motion (ROM) limitation of the joint [3]. Radiology such as X-ray, MRI, and CT are required to detect any soft tissue damages and seek for any metastasis [4].

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While osteosarcoma treatment often involves chemotherapy followed by surgical intervention such as carcinologic resection, amputation, and rotationplasty. The long-term functional outcomes depend significantly on effective post-operative rehabilitation [5].

Rotationplasty (RP) is a surgical procedure that was used long time ago for congenital and acquired lower extremity bone loss [6]. In 1974, RP was introduced as a limb-salvage procedure instead of performing the amputation [7].

RP is a limb salvage surgical procedure primarily performed in children and adolescents with osteosarcoma affecting the lower limb (distal femur and proximal tibia) [8]. During the procedure, the affected portion of the femur is resected, and the remaining lower leg, including the tibia, fibula, and foot, is then rotated 180 degrees and reattached to the remaining femur [9]. This rotation allows the foot to function as a knee joint. RP is a well-established reconstructive procedure following resection of lower extremity osteosarcoma [10].

It is an effective operation for patients with osteosarcoma, as they regain their movement functions closer to normal movement functions [7]. Post-operative complications, including limb ischemia and infection, are a concern following RP and require careful monitoring, as they can lead to further amputation if neglected [11].

Physiotherapy management for patients with RP includes pre-operation management, post-operation management, and post-prosthetic management [12]. Post-operatively, at day 1, patients with RP should be provided with assistive devices and start ambulation on the non-affected side [12]. Also, the affected side should be immobilized by a cast for 2 months. Nevertheless, patients should continue exercises targeting both bilateral upper extremities and the non-affected lower extremity, including strengthening and endurance exercises, to enhance reliance on these limbs for ambulation. After removing the cast, patients should start bear weight on the affected side partially [12]. After removing the cast, ROM exercise should be implemented to avoid contractures [12].

After applying the prosthesis, patients should continue the physiotherapy treatment specifically for the affected side. The treatment includes strengthening exercise, ROM exercise and endurance exercise with regards to all the 4 extremities and core muscles [12].

Early and prolonged physiotherapy is essential for patients with RP to prevent complications such as contractures, loss of endurance, muscle weakness, and muscle wasting [13]. Previous studies did not mention the short-term effect before applying the prosthesis [14].

While the importance of physiotherapy in rotationplasty rehabilitation is recognized, there is a need for more research examining the effects of structured physiotherapy programs prior to prosthetic fitting. Building on previous research that demonstrated the effectiveness of physiotherapy interventions in improving functional outcomes for patients undergoing rotationplasty, this case study examines the impact of an 8-week physiotherapy regimen, initiated immediately post-operatively, on health-related quality of life and walking speed in a pediatric patient undergoing rotationplasty for osteosarcoma. We hypothesized that an 8-week targeted physiotherapy program would lead to measurable improvements in these key functional outcomes before the application of a prosthesis.

Materials and Methods

Study Design

Case study.

Case Description

This is a case of a 12-year-old boy diagnosed with osteosarcoma of the left distal femur. As the indication has been noted in the diagnosis, the operation performed was left distal osteosarcoma wide margin resection and Van nes rotationplasty by the surgeons.

The patient underwent left distal osteosarcoma wide margin resection and Van Nes rotationplasty. Pre-operative planning, including determination of osteotomy levels, was guided by MRI and long leg films. The specimens removed were left knee including distal femur, proximal tibia and fibula, skin, muscles, and subcutaneous tissue, along with posterior left knee flap. A circumferential incision was done around the mid-thigh at the level of the planned osteotomy all around. A second incision was made oval shaped distal to the tibial tubercle and the incisions were connected via a medial incision overlying the course of the femoral neurovascular bundle, and a lateral incision just posterior to the iliotibial (IT) band.

The surgical procedure consisted of left distal osteosarcoma wide margin resection and Van Nes rotationplasty. Standard surgical techniques were employed, including resection of the affected portion of the femur and rotation of the lower leg for reattachment.

Following rotation of the lower leg, osteosynthesis was performed to secure the limb. Muscle reattachment and wound closure were carried out using standard surgical techniques. Figure 1 shows a radiograph of the patient's femur post-operatively.

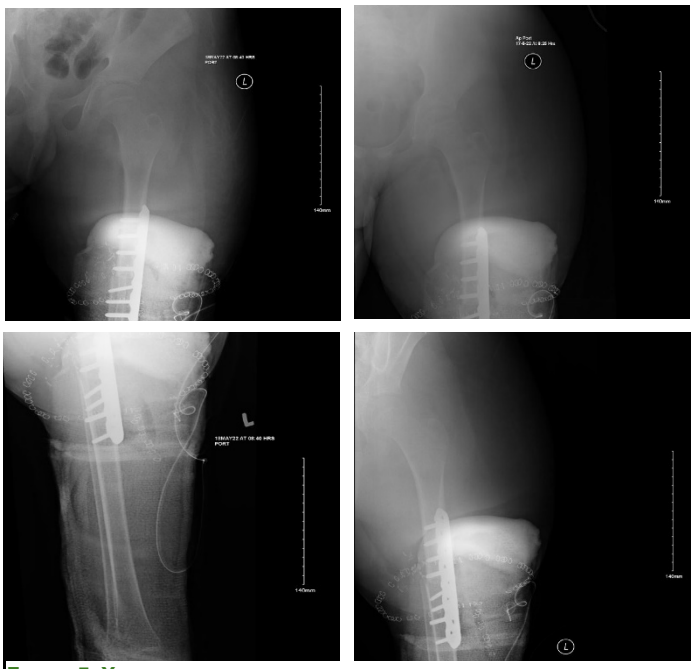

FIGURE 5: X-RAY OF THE LEFT FEMUR, POST-ROTATIONPLASTY

Patient exhibited a limited ROM in the left ankle, with dorsiflexion measured at 5 degrees and plantarflexion at 20 degrees. Manual muscle testing revealed notable weakness in the left lower extremity, with the following muscle strength grades: quadriceps 3/5, hamstrings 4/5, ankle dorsiflexors 2/5, and ankle plantarflexors 3/5. The patient ambulated with a pronounced antalgic gait pattern, relying heavily on a walking frame for support, and required moderate assistance with transfers.

Rehabilitation Program

The rehabilitation program primarily focused on physiotherapy interventions; however, it also encompassed other key components, including:

• Patient Medical History: A 12-year-old boy diagnosed with left-distal femoral osteosarcoma underwent rotationplasty. His medical history was otherwise unremarkable. Recent radiology images (MRI and long leg films) were reviewed to inform the pre-operative surgical planning and guide the post-operative physiotherapy approach.

• Psychological Well-being: The rehabilitation program included regular informal discussions with the patient and his family to address any emotional concerns related to the surgery and rehabilitation process. These discussions focused on providing encouragement, addressing anxieties, and promoting a positive mindset towards the training sessions. The patient's emotional well-being and motivation were monitored throughout the program, and adjustments were made to the training schedule as needed to accommodate his emotional state.

• Patient Comfort: The rehabilitation program prioritized the patient's comfort during sessions. This approach included ensuring the patient wore comfortable clothing and appropriate footwear, with insoles provided for the right lower extremity as needed. Furthermore, sessions were conducted in a private setting, with only the patient and his parents in attendance.

The rehabilitation program consisted of four phases, beginning with inpatient care and transitioning to outpatient care at a rehabilitation clinic.

Phase I: Day 1 post-operative until discharge from the hospital:

Deep breathing exercises were performed 4 times daily, 10 repetitions each time. Ankle pumping exercises (10 repetitions, 4 times daily) and straight leg raises (SLR) with a 5-second hold (5 repetitions, 3 times daily) were initiated. Ambulation with a walker was encouraged as tolerated, starting with short distances (2 meters) and gradually increasing the distance as the patient's strength and comfort improved. Assistance was provided as needed to ensure safety.

Phase II: Post discharge, out-patient rehabilitation program:

The primary goal of Phase II was to improve the patient's functional mobility, strength, and ROM following hospital discharge, preparing him for increased weight-bearing and eventual prosthetic fitting.

1. ROM exercises for the left ankle were performed, including active dorsiflexion, plantarflexion, inversion, eversion, and circumduction. These exercises were conducted in 3 sets of 15 repetitions, twice daily
2. Gentle Stretching Exercises for the Left Ankle Muscles: Stretch performed passively by placing the affected leg out of the bed while the patient laying in supine position. Held for 30 seconds, 3 repetitions.

3. Gentle Ankle Joint Mobilization for Dorsiflexion: Grade I and II ankle joint mobilizations were performed by the therapist to improve dorsiflexion range. Mobilizations consisted of gentle oscillations and glides, performed for 5 minutes.
4. Strengthening exercises for the Right Lower Extremity: Right quadriceps, right hamstring, and right calf muscles strengthening exercises were performed using a resistance band for 3 sets of 10 repetitions.
5. Strengthening exercises for Bilateral Upper Extremities: Bicep, triceps, and shoulder abductors muscles strengthening exercises were performed using a resistance band for 3 sets of 10 repetitions.
6. Strengthening exercises for the Upper Back Muscles: Scapular retractions, squeezing the shoulder blades together, 3 sets of 15 repetitions. Furthermore, Seated rows using a resistance band for 3 sets of 10 repetitions were performed.
7. Gluteus Maximus and Gluteus Medius Activation exercises: Gluteus maximus activation exercise performed in standing, squeezing the buttocks together. Held for 5 seconds, 10 repetitions, while hip abduction exercise performed in side-lying, lifting the top leg away from the midline. 3 sets of 10 repetitions to activate the gluteus medius.
8. Sit-to-stand exercises were performed on the right lower extremity, utilizing a chair with armrests and a ladder for balance and support. As the patient's strength improved, the height of the chair was progressively reduced. The exercises were performed for 5 repetitions.
9. Gait Exercise: Gait training was performed using a walker. The patient walked 20 meters with the walker, focusing on a heel-toe gait pattern and equal weight-bearing on both lower extremities. The therapist provided verbal cues and manual assistance as needed. Gait training was performed 2 times per week.

Phase III: 2 months post-operation:

This phase focuses on continuing the exercises from Phase II, progressing them as appropriate, and introducing partial weight-bearing and hip strengthening exercises.

1. ROM Exercises for the Left Ankle: Continue with the same ROM exercises as in Phase II (dorsiflexion, plantarflexion, inversion, eversion, circumduction), but increase the repetitions to 20 per set and the hold time for stretches to 45 seconds if tolerated. Monitor the patient's progress and adjust the program as needed.
2. Gentle stretching exercises for the Left Ankle Muscles: Continue with the same stretching exercises as in Phase II but increase the hold time to 45 seconds and the repetitions to 4 if tolerated.
3. Gentle Ankle Joint Mobilization for Dorsiflexion: Continue with Grade I and II mobilizations as needed, focusing on improving dorsiflexion.
4. Strengthening exercises for the Right Lower Extremity: Continue the exercises from Phase II (quadriceps sets, hamstring curls, calf raises) but increase the resistance by using a stronger resistance band.
5. Strengthening exercises for Bilateral Upper Extremities: Continue the exercises from Phase II (bicep curls, triceps extensions, shoulder abduction), increasing resistance or as appropriate.
6. Strengthening exercises for the Upper Back Muscles: Continue the exercises from Phase II (scapular retractions, rows), increasing the resistance.
7. Gluteus Maximus Activation exercises: Continue the exercises from Phase II, focusing on proper form and increasing the hold time for standing activation to 10 seconds.
8. Gluteus Medius Strengthening exercises (Side-Lying): Continue the hip abduction exercise from Phase II, increasing the resistance.
9. Sit-to-stand on the Right Lower Extremity (with ladder assistance): Progress the sit-to-stand exercises by gradually decreasing the height of the chair. Increase the repetitions to 8-10.
10. Gait exercise: Continue gait training with the walker, gradually increasing the distance walked and focusing on improving gait pattern, balance, and weight-bearing. Introduce variations in gait training, such as walking backward.
11. Partial Weight-Bearing on the Left Lower Extremity: Partial weight-bearing exercises were initiated on the left lower extremity using a progressive stacking method. Initially, a stable wooden box was used to elevate the limb.
12. As shown in Figure 2, a stack of folded towels was placed on top of the box to further elevate the limb and reduce the amount of weight placed on the affected leg.
13. Left Hip Strengthening Exercises: Left hip flexion, extension, abduction, and adduction strengthening exercises were performed with a resistance band for 3 sets of 10 repetitions.

FIGURE 6: PARTIAL WEIGHT BEARING ON THE LEFT LOWER EXTREMITY

Phase IV: Pre-prosthesis application:

1. Left Ankle ROM Exercises: The goal of this phase is to maximize ankle ROM in preparation for prosthetic fitting. Active ankle dorsiflexion plantarflexion, inversion, eversion, and circumduction were performed. 3 sets of 15 repetitions, holding each repetition for 5 seconds.
2. Ankle stretching exercises targeting the gastrocnemius, soleus, and tibialis anterior muscles were performed. Each stretch was held for 30 seconds, with 3 repetitions per muscle group.
3. Strengthening exercises for the Left Ankle: The focus is on strengthening the ankle musculature to support prosthetic use. Plantarflexion, dorsiflexion, inversion, and eversion against resistance was performed using a resistance band; 3 sets of 10 repetitions.
4. Gait training on the Parallel Bars and with the walking frame: The goal is to prepare the patient for prosthetic gait training by improving balance, weight-bearing, and gait pattern.

- Parallel Bars: Gait training was initiated on the parallel bars. The patient practiced weight shifting, balance reactions, and stepping patterns while using the bars for support. The therapist provided manual assistance as needed to ensure safety and proper technique. Sessions lasted for 15-20 minutes.
- Walking Frame: As the patient's balance and strength improved, gait training progressed to a walking frame. The patient practiced walking with the frame, focusing on a heel-toe gait pattern and equal weight-bearing on both lower extremities. The therapist provided verbal cues and supervised the patient's gait. The distance walked gradually increased as the patient progressed. Sessions lasted for 20-25 minutes.
- Pre-prosthetic gait training: specific pre-prosthetic gait training exercises were introduced, including step-ups onto a small platform to simulate prosthetic limb advancement and balance exercises with reduced upper extremity support.

Outcome measure

EQ-5D-5L:

The EQ-5D-5L is a standardized, patient-reported outcome measure developed by the EuroQol Research Foundation. It assesses health-related quality of life across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is rated on a 5-level scale, ranging from 'no problems' to 'extreme problems.' The responses are then converted into a single index score, which represents overall health-related quality of life [15]. Additionally, a visual analogue scale (VAS) is included, allowing patients to rate their overall health on a scale from 0 to 100, where 0 represents the 'worst imaginable health' and 100 represents the 'best imaginable health.' The EQ-5D-5L has demonstrated excellent psychometric properties across various populations and clinical settings [16,17].

10-meter walk test:

10-meter walk test (10MWT) is a performance measure designed to detect the walking speed in meters per second (m/s) within a short distance. Additionally, 10MWT would determine the functional mobility, gait and vestibular functions [18]. 10 MWT can be tested with assistive devices or while applying the prosthesis [19]. 10 MWT requires a 10-meter distance to conduct the test, it also requires 2-meters before starting the test and 2-meters once reaching the end of the 10-meter distance for acceleration and deceleration [20].

A 10-meter walkway was marked with tape, including 2 meters of acceleration space before the start line and 2 meters of deceleration space after the finish line. The patient was instructed to walk as quickly and safely as possible through the 10-meter distance. Patient was asked

to walk beyond the finish line to avoid decelerating before the end of the measured distance. The time taken to traverse the 10-meter distance was recorded using a stopwatch [18].

Ankle ROM:
Ankle ROM was assessed using a standard goniometer. For dorsiflexion and plantarflexion measurements, the patient was positioned supine. The stationary arm of the goniometer was aligned along the longitudinal axis of the fibula, using the lateral malleolus as a point of reference. The moving arm was aligned along the longitudinal axis of the fifth metatarsal, using the fifth metatarsal head as a point of reference. The axis of the goniometer was placed over the lateral malleolus.

Data analysis

The scores of EQ-5D-5L, 10-meter walk test, and ROM were retrieved in the table to demonstrate an overview of the outcomes before and after the intervention.

Administrative and Ethical Considerations

Ethical approval was obtained by the institutional review board (IRB) at King Abdullah International Medical Research Center (KAIMRC) with reference number: NRJ23J/022/01. A written consent form was taken from the participant and his caregivers.

Results

EQ-5D-5L:

Baseline:

Patient reported that he has severe problems in walking about (MOBILITY) while using the walking frame; has moderate problems washing or dressing himself (SELF-CARE); has severe problems doing his usual activities (USUAL ACTIVITIES); has moderate pain or discomfort (PAIN/DISCOMFORT); he is slightly anxious depressed (ANXIETY/DEPRESSION); his health=94%.

4 weeks post-physiotherapy intervention:

Patient reported that he has slight problems in walking about (MOBILITY) while using the walking frame; has slight problems washing or dressing himself (SELF-CARE); has moderate problems doing his usual activities (USUAL ACTIVITIES); has moderate pain or discomfort (PAIN/DISCOMFORT); he is not anxious depressed (ANXIETY/DEPRESSION); his health=96%.

2 months post-physiotherapy intervention:

Patient reported that he has no problems in walking about (MOBILITY) while using the walking frame; has no problems washing or dressing himself (SELF-CARE); has slight problems doing his usual activities (USUAL ACTIVITIES); has slight pain or discomfort (PAIN/DISCOMFORT); he is not anxious depressed (ANXIETY/DEPRESSION); his health=99%.

10-meter walk test:

The result of 10-meter walk test is demonstrated in Table 1. The patient completed this test three times: at baseline, after 4 weeks of intervention, and 2 months post-intervention, just prior to the application of the prosthesis.

TABLE 11: IMPROVEMENT IN 10-METER WALK TEST WALKING SPEED OVER 8 WEEKS OF PHYSIOTHERAPY INTERVENTION

PERIOD	S/10M	M/S
Baseline	32 s/10m	0.31 m/s
4 Weeks Post Physiotherapy Intervention	18 s/10m	0.55 m/s
2 Months Post Physiotherapy Intervention	12 s/10m	0.83 m/s

Ankle ROM:

ROM assessments were conducted at baseline, 4 weeks post-intervention, and 2 months post-intervention.

The rehabilitation program resulted in noticeable improvements in the left ankle ROM to 20±5 degrees for dorsiflexion and 75 degrees for plantar flexion using a goniometer. Table 2 demonstrates the improvement of ankle ROM.

TABLE 12: IMPROVEMENT IN ANKLE DORSIFLEXION AND PLANTARFLEXION ROM OVER 8 WEEKS OF PHYSIOTHERAPY

	DORSIFLEXION	PLANTER FLEXION
Baseline	-15^{O}	50^{O}
4 Weeks Post Physiotherapy Intervention	10^{O}	60^{O}
2 Months Post Physiotherapy Intervention	20^{O}	75^{O}

Post-Prosthesis Follow-up:
The participant demonstrated very good improvement functionally and psychologically. He was able to walk with the crutches instead of walker. He reported that he is very satisfied with his new prosthesis. Figure 3 demonstrates the application of the prosthesis. However, continued rehabilitation is necessary to enhance the patient's independence and to improve the flexibility of the left ankle joint, thereby facilitating better mobility of the prosthesis in both flexion and extension.

A. Prosthesis Application in Standing Position

B. Prosthesis Application (Anterior View)

C. Prosthesis Application (Lateral View)

FIGURE 7: PROSTHESIS APPLICATION IN DIFFERENT POSITIONS AND KNEE DIRECTIONS

Discussion

This study aimed to investigate the 8-week effect of physiotherapy intervention prior to prosthesis application for patients with RP. Consistent with our hypothesis, the 8-week physiotherapy intervention demonstrated effectiveness in improving health status and functional mobility prior to prosthesis application.

According to the results, there was a noticeable improvement in the patient's walking speed and health status over the course of the 8-week physiotherapy intervention. It is important to note that the patient utilized assistive devices (walker and then crutches) during the 10-meter walk test, which naturally influences walking speed. Therefore, direct comparisons to normal, unassisted walking speeds are not appropriate. The 10-meter walk test was conducted prior to prosthesis application to evaluate the impact of the physiotherapy intervention on the patient's pre-prosthetic functional mobility. This assessment provides valuable information about the effectiveness of the rehabilitation program in improving walking speed before the influence of the prosthesis. Post-prosthetic 10-meter walk tests would provide further insight into the patient's functional progress with the prosthesis and should be considered for future assessments.

Although the patient reported an improved health status according to the EQ-5D-5L assessment, he continued to require assistance with certain daily activities. This observation highlights the ongoing rehabilitation needs of patients following rotationplasty. Future interventions could explore the potential benefits of integrating occupational therapy to address activities of daily living. Occupational therapy can play a particularly significant role in helping post-operative patients regain independence in their daily lives [21]. Furthermore, the impact of prosthetic fitting and subsequent rehabilitation on the patient's independence should be considered [22]. It is also important to consider that this specific physiotherapy intervention may not be effective for every patient.

Left ankle ROM exercises were implemented as part of the patient's rehabilitation program. As shown in Table 2, these exercises demonstrably increased the patient's ankle ROM. Improved ankle mobility is a key factor in successful prosthesis application [23]. This is because greater ankle mobility allows for better fitting and smoother movement with the prosthesis, ultimately leading to improved gait and function [24].

This case report demonstrates the potential benefits of an 8-week structured physiotherapy intervention, initiated immediately post-operatively, in improving health-related quality of life and walking speed in a child following

rotationplasty. While the patient demonstrated significant improvements in functional outcomes, further research is required to establish the optimal timing and components of physiotherapy interventions for this patient population. Specifically, randomized controlled trials are needed to investigate the effectiveness of early physiotherapy interventions, including ROM exercises and muscle strengthening techniques, initiated on day 1 post-rotationplasty. This case study contributes to the existing literature by highlighting the importance of pre-prosthetic rehabilitation and the need for further investigation in this area.

Limitations

This study is limited by its single case study design, which restricts the generalizability of the findings. The absence of a control group limits our ability to determine the specific effects of the physiotherapy intervention compared to natural recovery or other potential factors. While the EQ-5D-5L provides valuable patient-reported data, it is a subjective measure and may be influenced by individual perceptions and biases. The follow-up period was limited to the pre-prosthetic phase, and long-term outcomes were not assessed. The patient was a 12-year-old male with osteosarcoma, and the findings may not be applicable to other patient populations. Due to the single case study design, no statistical analysis was performed. Therefore, we cannot determine the statistical significance of the improvements observed. Furthermore, the specific 8-week physiotherapy protocol used in this case may not be representative of all physiotherapy interventions for this patient population. Consequently, the findings of this case study are limited in their generalizability to a broader patient population.

Conclusion

This case report highlights the potential benefits of an 8-week structured physiotherapy intervention, initiated immediately post-operatively, in enhancing health-related quality of life and walking speed in a pediatric patient following rotationplasty. The patient demonstrated notable improvements in functional outcomes. However, due to the inherent limitations of a single case study, further rigorous, controlled studies, particularly randomized controlled trials, are necessary to establish evidence-based guidelines for physiotherapy management following rotationplasty. This case study contributes to the existing literature by highlighting the importance of pre-prosthetic rehabilitation and the need for further investigation in this area.

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Ethical approval statement

Ethical approval was obtained by the institutional review board (IRB) at King Abdullah International Medical Research Center (KAIMRC) with reference number: NRJ23J/022/01. A written consent form was taken from the participant and his caregivers.

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Conflicts of interest

The authors report there are no competing interests to declare.

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تأثير برنامج علاج طبيعي منظم لمدة 8 أسابيع على جودة الحياة جودة الحياة المرتبطة بالصحة وسرعة المشي لدى طفل بعد عملية تدوير الأطراف: دراسة حالة

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المستخلص:
غالبًا ما يواجه الأطفال الذين يخضعون لعملية تدوير الأطراف لعلاج سرطان العظام مجموعة من التحديات بعد الجراحة، بما في ذلك ضعف العضلات وصعوبات في المشي. هدفت دراسة الحالة هذه إلى تقييم تأثيرات برنامج علاج طبيعي منظم لمدة 8 أسابيع على هذه القيود الوظيفية، بالإضافة إلى جودة الحياة المتعلقة بالصحة وسرعة المشي، ومدى حركة مفصل الكاحل لدى طفل قبل تركيب الطرف الاصطناعي. تلقى صبي يبلغ من العمر 12 عامًا عملية تدوير الأطراف لعلاج سرطان العظام في عظم الفخذ البعيد الأيسر. تم تطبيق برنامج علاج طبيعي منظم، بدأ فورًا بعد الجراحة ومرورًا بسلسلة من المراحل المصممة خصيصًا لقدرة المريض الوظيفية المتطورة. تم تقييم نتائج تقرير التقييم الذاتي لمقياس التماثل البصري (VAS) لمقياس جودة الحياة (QE-5D-5L) وأداء اختبار المشي لمسافة 10 أمتار ومدى حركة مفصل الكاحل عند خط الأساس، وبعد 4 أسابيع، وبعد شهرين من تدخل العلاج الطبيعي، مما يمثل المراحل الرئيسية في مرحلة التأهيل قبل تركيب الطرف الاصطناعي، والتي تم خلالها تقييم التحسينات في جودة الحياة المتعلقة بالصحة وسرعة المشي ومدى حركة مفصل الكاحل. زادت نتائج مقياس التماثل البصري (VAS) لمقياس جودة الحياة (QE-5D-5L) من 94% إلى 99%، وزادت سرعة المشي من 0.31 متر/ثانية إلى 0.83 متر/ثانية، وزاد مدى حركة مفصل الكاحل في الانثناء الظهري من -15 درجة إلى 20 درجة، وفي الانثناء الأخمصي من 50 درجة إلى 75 درجة. تشير هذه النتائج إلى أن البدء المبكر للعلاج الطبيعي، الذي يتضمن تمارين تقوية، وتدريب على المشي، وتمارين التوازن، مفيد لتحسين النتائج الوظيفية لدى مرضى الأطفال بعد عملية تدوير الأطراف

الكلمات الدالة: سرطان العظام، العلاج الطبيعي، الحالة الصحية، سرعة المشي، تدوير الأطراف

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